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BULLETIN No. 13.

THE COMPOSITION OF SOME HAWAIIAN FEEDING STUFFS.

BY

EDMUND C. SHOREY,

CHEMIST, HAWAII AGRICULTURAL EXPERIMENT STATION.

UNDER THE SUPERVISION OF

OFFICE OF EXPERIMENT STATIONS,

U. S. Department of Agriculture.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1906.

HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

[Under the supervision of A. C. True, Director of the Office of Experiment Stations, United States Department of Agriculture.]

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LETTER OF TRANSMITTAL.

HONOLULU, HAWAII, *March 15, 1906.*

SIR: I have the honor to transmit and recommend for publication as Bulletin No. 13, of this station, the accompanying paper on The Composition of Some Hawaiian Feeding Stuffs, by Dr. Edmund C. Shorey, the station chemist.

Very respectfully,

JARED G. SMITH,
Special Agent in Charge.

DR. A. C. TRUE,
Director, Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Recommended for publication.

A. C. TRUE,
Director.

Publication authorized.

JAMES WILSON,
Secretary of Agriculture.

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COMPOSITION OF SOME HAWAIIAN FEEDING STUFFS.

INTRODUCTION.

In animal life there is continual breaking down and consumption of the substances of the body. The mere performance of the body functions, the act of living, results in the destruction of tissue. To supply new material in the place of substances so used is one of the chief functions of food. In addition, food furnishes the energy which enables the animal to carry on its life processes and to perform its necessary work, and in so doing maintains the heat of the body. When growth is to be made or milk secreted more food is required than for maintenance only. The scientific feeding of stock consists in supplying food in the right proportion to meet the requirements of the animal without waste of nutritive material. To so feed it is necessary, in the first place, to know the requirements of the animal and the relative nutritive value of different feeding stuffs. Feeding standards have been devised on the basis of experience and experiments, which within limits show kinds and amounts of nutritive material which the animal requires, and such standards are expressed in chemical terms. It is evident, therefore, that in a consideration of the kinds and amounts of feeding stuffs required to meet the demands of the standards a knowledge of their chemical composition is required. Thousands of analyses of feeding stuffs have been reported by investigators in the agricultural experiment stations and by others interested in the study of feeding problems, and a great deal of information is readily accessible regarding the composition of the forage crops, fresh and cured, and the grains, seeds, and other concentrated feeds used in Europe and America for feeding farm animals.

Frequent requests for information regarding the composition of Hawaiian-grown feeding stuffs have come to this station, including not only the commonly cultivated plants, whose average composition is fairly well known, but also many materials of which no analyses have been available. With regard to the commonly cultivated plants of which analyses are available, the question arose as to how far the average analyses of plants grown elsewhere represent the composition of Hawaiian-grown crops. In other words, it is desirable to know whether our climate, soil, and methods of cultivation exercised any special effect upon the composition of the crop.

To answer this question and also to supply data with regard to Hawaiian-feeding stuffs, concerning which few, if any, analytical data were available, a series of analyses was planned as part of the regular routine work of the station chemical laboratory. The first installment of analyses is reported in this bulletin.

Unless otherwise stated the samples of the forage plants analyzed were taken when the plant was in the condition in which it is usually cut for fodder. In the case of wild plants the samples were usually taken in the flowering stage. The method of preparation of samples was to chop a weighed portion, usually 500 grams, expose this in a shallow tray until air dried, weigh again, recording the loss on air drying, grind, pass through a millimeter sieve, and store in a tight sample bottle. This treatment insured thorough mixing, and it is believed a fair sample resulted. Both proximate and ash constituents were determined. The methods used throughout were those adopted by the Association of Official Agricultural Chemists.[a]

For the ash ingredients potash, lime, and phosphoric acid, separate portions were used, that for potash being ignited with sulphuric acid, that for phosphoric acid with magnesium nitrate.

In presenting the analytical data the materials have been grouped in most cases according to their botanical relationship, the tabular matter for each group being preceded by a description of the samples, data regarding their origin, etc.

NONSACCHARINE AND SACCHARINE SORGHUMS.

The nonsaccharine and saccharine sorghums analyzed included sorghum, sugar-cane tops, millet, and Kafir corn. In Hawaii sorghum is more usually grown than any other cultivated forage crop. It has the advantage that it grows well on a great variety of soils, and even with a moderate rainfall and little cultivation rattoons freely. Little attention has been paid thus far to the varieties grown, except that for the most part they are those which furnish green foliage rather than a saccharine stalk.

Of the five samples of sorghum analyzed, only one was a known variety, namely, No. 3 of the table below. This was designated "Madagascar" and was grown on the station grounds from imported seed. Sample No. 1 was also grown on the station grounds, No. 2 at Manoa Valley, No. 4 at Waialae, and sample No. 5 at Kapahula, all in the vicinity of Honolulu.

Considered from the standpoint of the amount of fodder consumed in Honolulu, sugar-cane tops exceed many times all other green fodders combined. Cane tops and barley form the regular ration for stock on or in the vicinity of plantations. The sugar-cane top samples examined were all from Lahaina cane, grown on the station grounds. Sample No. 1 was from cane 10 months old, samples No. 2 and No. 3

[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 46, revised.

from cane 18 months old. In the case of sample No. 2 the top was cut low enough to include a portion of the stalk.

Millet (*Sorghum halepense*) and Kafir corn are cultivated to some extent on dairy ranches in Hawaii, and two samples each of these crops were analyzed. Millet No. 1 was obtained from Ahuimanu and Millet No. 2 from Kamehameha schools. Both samples of Kafir corn were from Wahiawa.

The composition of the various sorghums is shown in the following table:

TABLE 1.—*Composition of nonsaccharine and saccharine sorghums.*

Kind of feeding stuff.	Proximate constituents.						Ash constituents.		
	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Potash.	Lime.	Phosphoric acid.
Sorghum:	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Sample No. 1	78.12	1.28	0.36	12.72	5.75	1.77	0.42	0.05	0.15
Sample No. 2	62.56	1.98	.38	22.05	10.15	2.88	.70	.15	.19
Sample No. 3	79.10	.77	.76	8.98	8.23	2.16	.51	.05	.15
Sample No. 4	74.43	2.15	.39	11.11	10.17	1.75	.41	.05	.12
Sample No. 5	81.50	.78	.19	9.33	6.60	1.60	.45	.05	.14
Average	75.14	1.39	.42	12.84	8.18	2.03	.50	.07	.15
Sugar-cane tops:									
Sample No. 1	71.12	1.60	.35	18.09	7.20	1.64	.59	.01	.11
Sample No. 2	75.98	1.78	.46	12.51	7.75	1.52	.55	.04	.17
Sample No. 3	76.30	1.23	.45	13.54	6.98	1.50	.62	.04	.17
Average	74.47	1.54	.42	14.71	7.31	1.55	.59	.03	.15
Millet:									
Sample No. 1	75.53	2.81	.37	12.05	7.45	1.79	.65	.11	.14
Sample No. 2	80.82	2.07	.08	8.44	6.79	1.80	.37	.04	.13
Average	78.18	2.44	.22	10.25	7.12	1.79	.51	.075	.135
Kafir corn:									
Sample No. 1	79.69	1.65	.17	10.86	6.66	.97	.40	.01	.07
Sample No. 2	87.13	1.63	.23	2.60	7.05	1.36	.44	.04	.02
Average	83.41	1.64	.20	6.73	6.85	1.17	.42	.025	.045

From the figures in the above table it will be seen that the nonsaccharine and saccharine sorghums analyzed, like all green forage crops, contained a fairly large but variable percentage of water, the average being not far from 75 per cent. The fodders therefore contain on the average only about 25 per cent of nutritive material, carbohydrates (nitrogen-free extract and crude fiber) being the principal constituents. Considerable range in the proportion of the several nutrients in different samples of the same feeding stuff is noted, the analyses here reported corresponding in this respect to what has been noted by other observers elsewhere.

WILD AND CULTIVATED GRASSES.

Samples of thirteen varieties of wild and cultivated grasses were analyzed. Of the two samples of Guinea grass (*Panicum jumentorum*), which is raised to some extent on Hawaiian dairy ranches as a feed for milch cows, one sample, No. 1, came from Waialae, and the other, No. 2, from Ahuimanu.

Para grass (*Panicum molle*) is grown to some extent on nearly all dairy ranches near Honolulu. When the growth is slow, the grass is quite woody and not so readily eaten by stock as are more succulent fodders. All of the samples analyzed were grown on Oahu. No. 1 came from the Kamehameha schools, No. 2 from Waialae, No. 3 from Ahuimanu, and No. 4 from Nuuanu Valley.

Both samples of water grass (*Paspalum dilatatum*) analyzed were from Kamehameha schools. This grass under irrigation yields six to eight cuttings per annum, each cutting averaging 8 tons of green fodder per acre.

Paspalum orbiculare and barnyard grass (*Panicum crus-galli*), also cultivated grasses, were grown at the Kamehameha schools. The following eight grasses, namely, manienie or Bermuda grass (*Capriola* [*Cynodon*] *dactylon*), Hilo grass (*Paspalum conjugatum*), buffalo grass (*Stenotaphrum secundatum*), pilipiliuli (*Chrysopogon aciculatus*), kukaipua (*Syntherisma sanguinalis*), pili grass (*Heteropogon contortus*), yard grass (*Eleusine indica*), and *Chloris elegans*, were wild grasses found growing on the experiment station grounds.

The following table shows the composition of the grasses analyzed:

TABLE 2.—*Composition of grasses.*

Kind of feeding stuff.	Proximate constituents.						Ash constituents.		
	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Potash.	Lime.	Phosphoric acid.
Guinea grass (*Panicum jumentorum*):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Sample No. 1	63.93	1.88	0.19	21.42	8.29	4.29	0.71	0.22	0.18
Sample No. 2	65.02	2.03	.43	17.39	11.68	3.45	.90	.17	.15
Average	64.48	1.95	.31	19.41	9.98	3.87	.805	.195	.165
Para grass (*Panicum molle*):									
Sample No. 1	79.72	2.00	.14	8.18	7.89	2.07	.41	.06	.15
Sample No. 2	71.42	1.91	.30	12.56	10.00	3.81	.66	.08	.30
Sample No. 3	71.51	2.66	.43	11.61	11.68	2.11	.79	.09	.08
Sample No. 4	75.75	2.55	.30	11.32	6.85	3.23	.....	.....	.....
Average	74.60	2.28	.29	10.92	9.10	2.81	.62	.08	.18
Water grass (*Paspalum dilatatum*):									
Sample No. 1	75.77	2.82	.65	10.97	7.32	2.47	.60	.12	.11
Sample No. 2	71.47	3.09	.63	11.17	11.06	2.58	.62	.10	.26
Average	73.62	2.96	.64	11.07	9.19	2.52	.61	.11	.185
Paspalum orbiculare	57.13	2.13	.46	22.93	13.65	3.70	.46	.17	.10
Barnyard grass (*Panicum crus-galli*)	84.97	1.85	.33	5.51	5.80	1.54	.26	.02	.21
Manienie or Bermuda grass (*Capriola* [*Cynodon*] *dactylon*)	45.49	3.71	.32	32.62	12.50	5.36	.67	.14	.49
Hilo grass (*Paspalum conjugatum*)	70.07	1.41	.81	16.28	8.96	2.47	.52	.08	.26
Buffalo grass (*Stenotaphrum secundatum*)	63.09	1.44	.38	22.73	9.90	2.46	.35	.06	.23
Pilipiliuli (*Chrysopogon aciculatus*)	41.02	3.09	.36	36.04	16.26	3.23	.63	.02	.36
Kukaipua (*Syntherisma sanguinalis*)	58.96	4.50	.53	19.99	11.90	4.12	.70	.06	.30
Pili grass (*Heteropogon contortus*)	45.32	2.65	.76	27.14	17.80	6.33	.48	.26	.40
Yard grass (*Eleusine indica*)	77.77	1.87	1.02	9.17	7.45	2.72	.52	.04	.23
Chloris elegans	64.85	2.75	.51	16.44	11.25	4.20	.32	.08	.33

As a whole, the grasses analyzed contained a somewhat smaller proportion of water and somewhat larger proportions of nutritive material than the nonsaccharine and saccharine sorghums. As was the case with the sorghums, carbohydrates constituted the chief nutritive material.

LEGUMINOUS FORAGE CROPS.

Leguminous forage crops are, generally speaking, of special value on account of their fairly high protein content, as compared with grasses, and several sorts of leguminous crops were analyzed which were considered of especial interest in the feeding of animals in Hawaii.

Where irrigation is practicable in the vicinity of Honolulu, alfalfa is being very successfully grown. When once a good stand is obtained, it is possible to make from twelve to fifteen cuttings a year, and while data as to the weight obtained per cutting per acre are not available, it is certain that the yield is high. Of the samples analyzed, No. 1 of the table was Turkestan alfalfa from Waialae, cut young; No. 2, ordinary alfalfa from Waialae; and No. 3, from Kapahula.

The sample of the wild cowpea (*Vigna sandwichensis*) was grown at Wahiawa; Spanish clover (*Desmodium uncinatum*) and *Desmodium triflorum* were grown on the station grounds.

Table 3 shows the proximate and ash constituents of the leguminous forage crops analyzed:

TABLE 3.—*Composition of leguminous forage crops.*

Kind of feeding stuff.	Proximate constituents.						Ash constituents.		
	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Potash.	Lime.	Phosphoric acid.
Alfalfa:	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Sample No. 1	84.75	5.23	0.35	3.30	4.19	2.18	0.41	0.17	0.19
Sample No. 2	68.13	7.31	.44	10.20	10.32	3.60	.84	.45	.30
Sample No. 3	70.46	5.59	.48	12.74	7.89	2.84	.64	.41	.21
Average	74.45	6.04	.42	8.75	7.47	2.87	.63	.34	.23
Wild cowpea (*Vigna sandwichensis*)	73.11	3.47	.18	13.25	8.61	1.38	.46	.14	.09
Cowpea	86.16	2.63	.12	5.40	4.19	1.50	.35	.21	.09
Spanish clover (*Desmodium uncinatum*)	75.06	2.20	.19	14.36	7.21	.98	.17	.19	.09
Desmodium triflorum	65.22	5.03	1.42	13.92	11.65	2.76	.40	.10	.46

The leguminous forage crops analyzed showed a variable but generally high water content. They contain fairly high proportions of carbohydrates in proportion to their total nutritive material and on an average considerably more protein than the nonleguminous crops, the high protein content being a well-known characteristic of this class of plants.

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WEEDS USED AS FORAGE.

A number of weeds are used as feeding stuffs in Hawaii, and those considered of most importance were analyzed. The pigweed or purslane (*Portulaca oleracea*) and pualele or sow thistle (*Sonchus oleraceus*) were from the station grounds. These plants are both common in cultivated fields and when plentiful are frequently gathered for fodder, the pigweed particularly for pigs and ducks. Of the two samples of honohono (*Commelina nudiflora*), which is also a commonly cultivated crop, particularly in wet places, No. 1 was from the station grounds and No. 2 from Kamehameha schools. The sample of ki (*Bidens pilosa*) analyzed was obtained from Manoa Valley.

The following table summarizes the data regarding the weeds analyzed:

TABLE 4.—*Composition of some weeds used as forage.*

Kind of feeding stuff.	Proximate constituents.						Ash constituents.		
	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Potash.	Lime.	Phosphoric acid.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Pigweed or purslane (*Portulaca oleracea*)	95.20	1.04	0.09	2.18	0.53	0.96	0.23	0.03	0.05
Pualele or sow thistle (*Sonchus oleraceus*)	87.13	1.78	.74	5.85	2.57	1.93	.33	.10	.13
Honohono (*Commelina nudiflora*):									
Sample No. 1	86.45	1.17	.49	7.78	2.64	1.47	.37	.06	.11
Sample No. 2	92.41	1.38	.15	2.81	1.92	1.33	.40	.05	.09
Average	89.43	1.27	.32	5.30	2.28	1.40	.385	.055	.10
Ki (*Bidens pilosa*)	67.92	2.15	.45	19.59	7.15	2.74	.68	.70	.21

Most of the weeds analyzed were very succulent, that is, contained a very small proportion of nutritive material and a large proportion of water. The sample of ki (*Bidens pilosa*), however, differed from the others in this respect, the water content being fairly low and the proportion of nutritive material, especially nitrogen-free extract, being fairly high.

MISCELLANEOUS GREEN FORAGE PLANTS.

Cactus or prickly pear (*Opuntia ficus-indica*) fronds, kolu branches (*Acacia farnesiana*), and a number of waste products, including banana tops and butts, sweet-potato tops, and leaves of the ti plant (*Cordyline terminalis*) were analyzed. Of the two samples of cactus or prickly pear, No. 1 consisted of young fronds and No. 2 of old fronds. The kolu is a shrub common in waste places in Kona pastures, usually near the sea. Cattle often eat the young branches, leaves, pods, and flowers when other fodder is scarce. The samples selected were gathered when in flower.

The banana tops and butts analyzed were respectively the upper and lower half of large suckers grown on the station grounds. The sweet-

potato tops were also from the station grounds; the taro tops from Pauoa Valley, and the ti leaves, which are considered excellent fodder for horses and cattle, were gathered near Honolulu.

The following table shows the composition of these various materials:

TABLE 5.—*Composition of miscellaneous green forage.*

Kind of feeding stuff.	Proximate constituents.						Ash constituents.		
	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Potash.	Lime.	Phosphoric acid.
Prickly pear (*Opuntia ficus-indica*):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Young fronds	94.63	0.44	0.07	3.22	0.52	1.12	0.44	0.17	0.06
Old fronds	94.62	.39	.09	3.16	.61	1.13	.26	.26	.07
Average	94.63	.41	.08	3.19	.57	1.12	.35	.215	.065
Kolu (*Acacia farnesiana*)	60.00	6.87	.83	23.04	7.16	2.10	.65	.33	.74
Banana tops	84.29	2.08	.36	6.62	4.91	1.74	.43	.14	.08
Banana butts	94.22	.37	.14	2.02	2.20	1.05	.14	.03	.04
Taro tops	84.56	1.86	.49	10.29	1.42	1.38	.38	.12	.14
Sweet-potato tops	87.67	2.93	.36	6.08	1.69	1.27	.32	.13	.09
Ti leaves (*Cordyline terminalis*)	79.36	2.86	.63	8.90	6.38	1.87	.69	.11	.39

The prickly pear, banana tops, and other miscellaneous forage plants analyzed were in general found to contain small proportions of the different nutritive elements in addition to a large proportion of water. An exception is the kolu (*Acacia farnesiana*), which contained 23.04 per cent nitrogen-free extract, 6.87 per cent protein, and only 60 per cent water.

ROOTS.

The only root crop analyzed was cassava. Sample No. 1 of the following table was grown on the station grounds and sample No. 2 was obtained from Ahuimanu. The sample from the station grounds was long past maturity and very watery in composition, and may be fairly regarded as containing a minimum amount of starch. Cassava, extensively grown in all tropical countries, is very important both as a food and as a feeding stuff.

The following table shows the composition of the samples of cassava root analyzed:

TABLE 6.—*Composition of cassava roots used as forage.*

Kind of feeding stuff.	Proximate constituents.						Ash constituents.		
	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Potash.	Lime.	Phosphoric acid.
Cassava roots:	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Sample No. 1	84.69	0.82	1.27	10.67	1.41	1.14	0.36	0.07	0.02
Sample No. 2	62.80	.83	3.03	27.66	4.68	1.00	.47	.04	.19
Average	73.75	.82	2.15	19.17	3.04	1.07	.415	.055	.105

CONCENTRATED AND COMMERCIAL FOODS.

A number of concentrated and commercial feeds used in Hawaii were analyzed. Some of them, like brewers' grains and rice products, are the usual commercial articles; others, like the algeroba[a] or kiawe beans, are more typical of Hawaii.

The sample of brewers' grains was obtained from a brewing firm in Honolulu. The wet grains contained about 75 per cent of water, but the sample analyzed was air dried.

For a number of years a feeding stuff has been manufactured on the sugar plantations from the waste molasses and the dry, finer portions of bagasse. This material has usually been given the name of molasscuit, but more recently it has been on the Honolulu market under the name of "sugar bran." As the composition of waste molasses differs quite widely and the capacity of the bagasse to absorb the molasses is also variable, there is every reason to suppose that molasscuit would not be at all uniform in composition. This supposition is borne out by the analyses of the three samples. Sample No. 1 was obtained from a plantation on Hawaii. Sample No. 2 was obtained from the same source and made from same materials, except that the bagasse was dried before the molasses was added to it. Sample No. 3, a sample of sugar bran, was obtained in the Honolulu market.

The seed pods of *Prosopis juliflora* are known locally as algeroba or kiawe beans, the term "bean" being applied to the pod and the seed together. This tree, which is very common in the neighborhood of Honolulu and in many other places at sea level, is rapidly spreading up the valleys and to the higher levels, and the "beans" are assuming an important place among local feeding stuffs.

Owing to the fact that the seeds in the pods are extremely hard and are also protected by a seed coat, which can be detached only with difficulty, very few of the seeds are digested when the pods are fed whole or even coarsely chopped. In fact, it is to the germination of seeds which have passed through the digestive tract of animals whole and uninjured that the rapid spread of the tree is largely due. As the seeds contain much of the protein which appears on analysis of the whole pods, efforts have been made to grind the pods, so as to break the seeds and render them more digestible. It is impossible to do this with ordinary grinding machinery, owing to the sugary and gummy nature of the pod. Several local dairymen have attempted to interest manufacturers of grinding machinery in this matter, and samples of meal prepared by a mainland manufacturer appeared to be all that could be desired. In these samples the seeds were completely ground, but portions of the outer seed coat resisted grinding. Assuming that when

[a] This is not the true algarroba, and the spelling indicated is the usual Hawaiian one.

the beans are fed whole the protein in the seeds is wasted, any system of grinding which will render the seed protein available as food increases very materially the probable value of the bean. It will be seen by the analyses that the seeds contain a much larger percentage of protein than the remainder of the pods.

The algeroba bean samples included two specimens of beans (beans and pods) Nos. 1 and 2; samples of meal made from beans a year old, from fresh beans, and from seed coats; selected pods with the seeds removed; the seeds from selected pods; and average pods with the seeds removed; and the seeds from them.

The two samples of rice bran, Nos. 1 and 2, and the rice polish were purchased in the Honolulu market, as was also the sample of cocoanut meal.

The following table shows the composition of the concentrated and chemical feeds enumerated:

TABLE 7.—*Composition of some concentrated feeds and commercial products.*

Kind of feeding stuff.	Proximate constituents.						Ash constituents.		
	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.	Potash.	Lime.	Phosphoric acid.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Brewers' grains	9.05	18.06	2.76	46.08	20.34	3.71	0.21	0.25	1.15
Molasscuit:									
Sample No. 1	26.00	4.20	.10	55.68	7.00	7.02	.....	.....	.....
Sample No. 2	15.66	4.54	.16	61.12	10.86	7.66	2.40	.86	.29
Sample No. 3 (sugar bran)	21.95	2.27	.05	59.57	6.96	9.20	2.41	1.07	.60
Average	21.20	3.67	.10	58.80	8.27	7.96	2.405	.965	.445
Algeroba or kiawe beans (*Prosopis juliflora*):									
Whole beans (seeds and pods)—									
Sample No. 1	15.61	9.37	.63	48.62	22.88	2.89	1.39	.14	.34
Sample No. 2	14.91	8.41	.53	45.91	26.63	3.61	.....	.....	.....
Average	15.26	8.89	.58	47.27	24.75	3.25	.....	.....	.....
Meal—									
Beans (seeds and pods) 1 year old	11.36	9.87	.43	51.52	23.65	3.17	1.46	.34	.40
Fresh beans (seeds and pods)	12.30	7.34	.37	57.31	19.48	3.20	1.37	.28	.23
Seed coats	12.57	5.00	.37	47.26	32.74	2.06	1.32	.97	.27
Selected pods, seeds removed	18.15	6.52	.12	53.33	20.20	2.68	1.53	.20	.21
Seeds from selected pods	14.38	33.62	3.94	36.78	6.84	4.44	1.59	1.10	1.69
Average pods, seeds removed	17.49	4.62	.15	52.07	22.52	3.15	1.25	.30	.15
Seeds from average pods	14.24	30.18	4.50	38.90	7.78	4.40	1.56	1.00	1.72
Rice bran:									
Sample No. 1	9.55	7.12	11.01	31.19	28.97	12.16	1.01	.15	2.11
Sample No. 2	10.63	11.33	12.07	45.57	10.33	10.07	.99	.08	3.20
Average	10.09	9.23	11.54	38.38	19.65	11.11	1.00	.115	2.655
Rice polish	10.49	12.31	12.97	50.18	5.18	8.87	1.57	.15	4.90
Cocoanut meal	11.18	20.97	7.52	41.62	12.97	5.74	2.13	.08	1.64

The different samples of concentrated and commercial feeds, as is usual with this class of goods, showed a much lower water content

and much higher proportions of nutritive material than the succulent feeds analyzed. The range in the water content and the corresponding range in the proportion of nutritive ingredients was also much smaller than in the case of the succulent feeds. Nitrogen-free extract was the principal nutritive material present in the samples analyzed, though some of the materials, particularly dried brewers' grains, algeroba bean seeds, and cocoanut meal, contained high percentages of protein. Especially noteworthy is the protein content of the algeroba bean seeds, which averaged over 30 per cent.

HAWAIIAN FEEDS COMPARED WITH THOSE PRODUCED ELSEWHERE.

The agricultural experiment stations throughout the United States have analyzed a very large number of feeding stuffs, and from time to time this work has been summarized in station bulletins and in publications of the Department of Agriculture.[a] A comparison of available data indicates that as regards the nutrients which they contain Hawaiian feeding stuffs do not differ materially from similar materials produced elsewhere, the green forage crops being characterized by a high-water content and a comparatively low amount of nutritive material, and the concentrated feeds by much larger percentages of nutritive ingredients in proportion to their bulk.

No detailed comparison of Hawaiian and other feeds is made here, as it seems best to postpone such a discussion until the data regarding the composition of Hawaiian feeds are much more abundant. The analyses reported are, however, sufficient to show the high feeding value of many native materials, and indicate that satisfactory rations for farm animals may be made up from the local feed supply.

In discussing the value of any feed it should be remembered that digestibility must be taken into account as well as composition, since the animal lives upon the food assimilated rather than upon the food supplied. The digestibility of any feed may be best learned by means of digestion experiments in which records are kept of the amount and composition of the feed consumed and the amount and composition of the excretory products. It is hoped that such experiments may be carried on in connection with the study of Hawaiian feeding stuffs which the station has undertaken, but as yet it has seemed necessary to limit the feeding stuff investigation to studies of composition. There is no reason to suppose that the Hawaiian feeds would be inferior to other similar feeds in digestibility, and it seems fair to conclude that the proportion of digestible nutrients supplied by such feeding stuffs may be calculated on the basis of average factors whenever such calculations seem desirable.[b]

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[a] U. S. Dept. Agr., Office of Experiment Stations Bul. 11; Farmers' Bul. 22.

[b] A table of digestion coefficients will be found in U. S. Dept. Agr., Office of Experiment Stations Bul. 15.

It should be remembered, in considering the feeding value of any plant or feeding stuff, that palatability and wholesomeness must be considered as well as composition and digestibility. Some forage plants are unacceptable to stock on account of their physical condition, as is the case with the woody stalks of sorghum and Para grass, or on account of the presence of bitter or acrid flavoring principles. Woody materials, like those mentioned, may often be made more palatable by fine chopping. Then, too, grinding is often necessary in order that the feeding stuff may be assimilated, as was pointed out in the discussion of algeroba beans.

Of Hawaiian feeding stuffs which are not relished by stock on account of acrid or other unpleasant or disagreeable constituents, *Chloris elegans*, one of the grasses analyzed, may be cited. As shown by analysis this compares favorably with other grasses, yet stock will not eat it, although it is very common in our pastures. Two legumes grown at the station for green manuring, namely *Centrosema plumeri* and *Canavalia ensiformis*, may also be mentioned in this connection. *Centrosema plumeri* has the following percentage composition: Water 77.33, protein 4.76, fat 0.30, nitrogen-free extract 9.43, crude fiber 5.77, and ash 2.41 per cent; and *Canavalia ensiformis*, water 77.29, protein 3.66, fat 0.37, nitrogen-free extract 10.44, crude fiber 6.10, and ash 2.14 per cent. Judged by composition alone, these materials would have a higher feeding value than cowpeas or Spanish clover, but they actually have little or no value as a fodder since they are so unpalatable to live stock.

NUTRIENTS IN DRY MATTER OF HAWAIIAN FEEDING STUFFS.

In the preceding discussion the feeding stuffs have been considered on the fresh basis. In comparing the composition of different feeding stuffs calculated on this basis it is necessary, in order to avoid erroneous conclusions, to consider the water content in its relation to the other constituents present. For instance, the grasses manienie (*Capriola dactylon*) and kukaipua (*Syntherisma sanguinalis*) contain 3.71 and 4.50 per cent protein, respectively, while the legumes, cowpea and Spanish clover, contain but 2.63 and 2.20 per cent. When we remember, however, that these grasses contain but 45.49 and 58.96 per cent water, respectively, while the legumes contain 86.16 and 75.06 per cent, the apparent anomaly is explained, and it is seen that if the grasses and legumes were equally dry the latter would show the higher percentage of protein. It is, therefore, often desirable to compare different materials on the dry-matter basis, and such a comparison of the Hawaiian feeds analyzed is made in the table following.

TABLE 8.—*Summary of analyses of Hawaiian feeding stuffs.*

[Dry-matter basis.]

Kind of feeding stuff.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash constituents.		
					Potash.	Lime.	Phosphoric acid.
NONSACCHARINE AND SACCHARINE SORGHUMS.							
Sorghum:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sample No. 1	5.85	1.64	58.13	21.70	1.91	0.22	0.68
Sample No. 2	5.28	1.01	58.89	27.13	1.87	.40	.50
Sample No. 3	3.68	3.63	42.96	39.37	2.44	.24	.71
Sample No. 4	8.40	1.13	43.45	39.81	1.60	.19	.46
Sample No. 5	4.21	1.02	50.43	35.67	2.43	.27	.76
Average	5.48	1.69	50.77	32.74	2.05	.26	.62
Sugar-cane tops:							
Sample No. 1	6.30	1.13	60.34	24.01	1.46	.03	.36
Sample No. 2	7.41	1.91	52.07	32.25	2.28	.16	.70
Sample No. 3	5.18	1.89	57.13	29.45	2.61	.16	.67
Average	6.30	1.64	56.51	28.57	2.12	.12	.58
Millet:							
Sample No. 1	11.48	1.51	49.24	30.44	2.63	.45	.57
Sample No. 2	10.78	.42	55.00	35.40	1.92	.20	.67
Average	11.13	.96	52.12	32.92	2.27	.32	.62
Kafir corn:							
Sample No. 1	8.12	.83	53.47	32.79	1.96	.05	.34
Sample No. 2	12.64	1.78	20.20	54.85	3.41	.31	.15
Average	10.38	1.30	36.83	43.82	2.68	.18	.24
GRASSES.							
Guinea grass:							
Sample No. 1	5.21	.52	59.38	22.97	1.96	.60	.49
Sample No. 2	5.83	1.22	49.81	33.38	2.50	.48	.42
Average	5.52	.87	54.59	28.17	2.23	.54	.45
Para grass:							
Sample No. 1	9.86	.67	40.33	38.90	2.02	.29	.73
Sample No. 2	6.68	1.05	43.94	35.68	2.30	.28	1.04
Sample No. 3	9.33	1.50	40.75	40.99	2.77	.31	.29
Sample No. 4	10.51	1.23	46.67	28.25	.....	.....	.....
Average	9.10	1.11	42.92	35.96	2.36	.29	.69
Water grass (*Paspalum dilatatum*):							
Sample No. 1	11.63	2.68	45.27	30.21	2.47	.49	.45
Sample No. 2	10.83	2.20	39.15	38.76	2.17	.35	.91
Average	11.23	2.44	42.21	34.48	2.32	.42	.68
Paspalum orbiculare	4.96	1.07	53.48	31.84	1.07	.39	.23
Barnyard grass (*Panicum crus-galli*)	12.32	2.19	36.66	38.58	1.72	.13	1.39
Manienie or Bermuda grass (*Capriola* [*Cynodon*] *dactylon*)	6.86	.58	59.84	22.93	1.23	.25	.89
Hilo grass (*Paspalum conjugatum*)	4.71	2.30	54.39	29.93	1.73	.26	.46
Buffalo grass (*Stenotaphrum secundatum*)	4.12	1.09	62.33	28.23	1.00	.17	.65
Pilipiliuli (*Chrysopogon aciculatus*)	5.02	.61	61.15	27.56	1.06	.03	.61
Kukaipua (*Syntherisma sanguinalis*)	10.96	1.28	48.95	26.55	1.61	.14	.73
Pili grass (*Heteropogon contortus*)	4.84	1.38	49.79	32.53	.87	.47	.73
Yard grass (*Eleusine indica*)	8.41	4.58	41.25	35.51	2.33	.17	1.03
Chloris elegans	7.82	1.45	43.92	32.00	.91	.22	.91
LEGUMINOUS FORAGE CROPS.							
Alfalfa:							
Sample No. 1	34.29	2.29	21.64	27.46	2.67	1.11	1.24
Sample No. 2	22.93	1.38	32.00	32.38	2.63	1.41	.94
Sample No. 3	18.57	1.62	43.12	26.70	2.17	1.38	.71
Average	25.26	1.76	32.25	28.85	2.49	1.30	.96
Wild cowpea (*Vigna sandwichensis*)	12.98	.67	49.28	32.03	1.71	.51	.33
Cowpea	18.84	.85	38.86	30.27	2.52	1.51	.65
Spanish clover (*Desmodium uncinatum*)	8.82	.76	57.57	24.89	.68	.76	.36
Desmodium triflorum	14.42	4.07	39.90	33.40	1.14	2.00	1.32

TABLE 8.—*Summary of analyses of Hawaiian feeding stuffs*—Continued.

Kind of feeding stuff.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash constituents.		
					Potash.	Lime.	Phosphoric acid.
WEEDS USED AS FORAGE.							
Pigweed or purslane (*Portulaca oleracea*)	*Per cent.* 21.66	*Per cent.* 1.87	*Per cent.* 45.41	*Per cent.* 11.04	*Per cent.* 4.79	*Per cent.* 0.62	*Per cent.* 1.04
Pualele or sow thistle (*Sonchus oleraceus*)	13.82	5.82	45.54	12.20	2.56	.77	1.01
Honohono (*Commelina nudiflora*):							
Sample No. 1	8.63	3.61	57.41	19.49	2.73	.44	.81
Sample No. 2	17.91	1.93	37.84	24.99	5.20	.64	1.17
Average	13.27	2.77	47.62	22.24	3.96	.54	.99
Ki (*Bidens pilosa*)	6.70	1.40	61.06	22.28	2.11	2.18	.65
MISCELLANEOUS GREEN FORAGE.							
Prickly pear (*Opuntia ficus-indica*):							
Young fronds	8.19	1.30	60.33	9.68	8.19	3.16	1.11
Old fronds	7.25	1.11	58.73	11.33	4.83	4.83	1.30
Average	7.72	1.20	59.53	10.50	6.51	3.99	1.20
Kolu (*Acacia farnesiana*)	17.17	2.07	57.60	17.90	1.62	.82	1.85
Banana tops	13.20	2.29	42.13	31.89	2.73	.89	.50
Banana butts	6.40	2.42	35.46	38.58	2.42	.51	.69
Taro tops	12.04	3.17	66.64	9.19	2.46	.77	.90
Sweet-potato tops	23.19	2.91	49.39	13.70	5.59	.90	3.16
Ti leaves (*Cordyline terminalis*)	13.85	3.04	43.07	30.87	3.39	.53	1.88
ROOTS USED AS FORAGE.							
Cassava roots:							
Sample No. 1	5.35	8.29	69.69	9.27	2.35	.45	.13
Sample No. 2	2.23	8.14	74.35	12.60	1.26	.10	.41
Average	3.79	8.21	72.02	10.93	1.80	.27	.27
CONCENTRATED FEEDS AND COMMERCIAL PRODUCTS.							
Brewers' grains	19.85	3.04	50.65	22.36	2.30	2.74	1.26
Molassene:							
Sample No. 1	5.67	.13	75.24	9.46	.....	.....	.....
Sample No. 2	5.38	.18	72.46	12.87	2.40	.86	.29
Sample No. 3 (sugar bran)	2.90	.06	76.32	8.91	3.08	1.37	.75
Average	4.65	.12	74.67	10.41	2.74	1.11	.52
Algeroba or kiawe beans (*Prosopis juliflora*):							
Whole beans (beans and pods)—							
Sample No. 1	10.84	.77	56.40	26.48	1.60	.16	.38
Sample No. 2	9.88	.62	53.13	31.29	.....	.....	.....
Average	10.36	.69	54.76	28.88	.....	.....	.....
Meal—							
Beans 1 year old	11.14	.48	58.12	26.79	1.65	.38	.45
Fresh beans	8.37	.42	65.34	22.21	1.56	.31	.26
Seed coats	5.71	.43	54.04	37.45	1.50	1.10	.30
Selected pods, seeds removed.	7.96	.14	63.93	24.67	1.86	.24	.25
Seeds from selected pods	39.26	4.60	42.95	7.95	1.85	1.28	1.97
Average pods, seeds removed.	5.59	.18	63.10	27.29	1.51	.36	.18
Seeds from average pods	35.19	5.24	45.47	9.07	1.81	1.14	2.00
Rice bran:							
Sample No. 1	7.87	12.16	34.48	32.02	1.11	.16	2.33
Sample No. 2	12.67	13.50	50.99	11.56	1.12	.89	3.57
Average	10.27	12.83	42.73	21.79	1.11	.52	2.95
Rice polish	13.77	14.48	56.28	5.78	1.76	.16	5.47
Cocoanut meal	23.60	8.58	46.86	14.62	2.39	.09	1.85

FORMS OF NITROGEN.

In reporting analyses of fodders and feeding stuffs, the term protein is used to include the total nitrogenous material present, the amount of protein being ordinarily obtained by multiplying the total nitrogen present by the factor 6.25. It is well known that the protein group includes a number of constituents beside the true proteids, prominent among the nonproteid bodies being the amid group.

In connection with the analyses of Hawaiian feeds, the proteid and amid nitrogen as well as the total nitrogen were determined in many of the samples, the methods followed being those recommended by the Association of Official Agricultural Chemists.[a] The data obtained are summarized in the following table, which shows the total proteid and amid nitrogen and the calculated crude protein, true protein, and the amids as asparagin.

TABLE 9.—*Nitrogenous constituents of Hawaiian feeding stuffs.*

Kind of feeding stuff.	Total nitrogen.	Proteid nitrogen.	Amid nitrogen.	Crude protein (total N×6.25).	True protein (protein N×6.25).	Amids calculated as asparagin.
NONSACCHARINE AND SACCHARINE SORGHUMS.						
Sorghum:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sample No. 1	0.206	0.153	0.053	1.28	0.94	0.24
Sample No. 2	.318	.218	.100	1.98	1.36	.47
Sample No. 3	.124	.105	.019	.77	.65	.09
Sample No. 4	.345	.223	.122	2.15	1.39	.57
Sample No. 5	.126	.100	.026	.78	.62	.12
Sugar-cane tops:						
Sample No. 1	.258	.235	.023	1.60	1.46	.10
Sample No. 2	.287	.200	.087	1.78	1.25	.40
Sample No. 3	.198	.156	.042	1.23	.97	.19
Millet:						
Sample No. 1	.448	.368	.080	2.81	2.29	.37
Sample No. 2	.332	.248	.084	2.07	1.54	.39
Kafir corn:						
Sample No. 1	.264	.163	.101	1.65	1.01	.47
Sample No. 2	.261	.178	.083	1.63	1.10	.39
GRASSES.						
Guinea grass (*Panicum jumentorum*):						
Sample No. 1	.301	.218	.083	1.88	1.36	.39
Sample No. 2	.326	.227	.099	2.03	1.41	.46
Para grass (*Panicum molle*):						
Sample No. 1	.320	.257	.063	2.00	1.60	.29
Sample No. 2	.306	.241	.065	1.91	1.50	.30
Sample No. 3	.427	.229	.198	2.66	1.42	.93
Water grass (*Paspalum dilatatum*): Sample No. 1	.452	.385	.067	2.82	2.40	.31
Barnyard grass (*Panicum crus-galli*)	.297	.229	.068	1.85	1.42	.32
Manienie or Bermuda grass (*Capriola [Cynodon] dactylon*)	.596	.423	.173	3.71	2.64	.81
Hilo grass (*Paspalum conjugatum*)	.226	.199	.027	1.41	1.23	.12
Buffalo grass (*Stenotaphrum secundatum*)	.231	.181	.040	1.44	1.12	.18
Pilipiliuli (*Chrysopogon aciculatus*)	.496	.320	.176	3.09	2.00	.82
Kukaipua (*Syntherisma sanguinalis*)	.721	.539	.182	4.50	3.36	.85
Pili grass (*Heteropogon contortus*)	.425	.359	.066	2.65	2.43	.31
LEGUMINOUS FORAGE CROPS.						
Alfalfa:						
Sample No. 1	.838	.560	.278	5.23	3.49	1.30
Sample No. 2	1.170	.729	.341	7.31	4.55	1.60
Sample No. 3	.896	.652	.244	5.59	4.07	1.14
Wild cowpea (*Vigna sandwichensis*)	.557	.354	.203	3.47	2.20	.95
Cowpea	.421	.272	.149	2.63	1.69	.60
Spanish clover (*Desmodium uncinatum*)	.352	.298	.054	2.20	1.85	.25
Desmodium trifolium	.806	.795	.011	5.03	4.96	.05

[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 46, revised.

TABLE 9.—*Nitrogenous constituents of Hawaiian feeding stuffs*—Continued.

Kind of feeding stuff.	Total nitrogen.	Proteid nitrogen.	Amid nitrogen.	Crude protein (total N×6.25).	True protein (protein N×6.25).	Amids calculated as asparagin.
WEEDS USED AS FORAGE.						
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Pigweed or purslane (*Portulaca oleracea*)	0.168	0.086	0.082	1.04	0.53	0.38
Pualeie or sow thistle (*Sonchus oleraceus*)	.285	.210	.075	1.78	1.31	.35
Honohono (*Commelina nudiflora*): Sample No. 1	.221	.182	.039	1.38	1.13	.18
Ki (*Bidens pilosa*)	.346	.270	.076	2.15	1.68	.35
MISCELLANEOUS GREEN FORAGE.						
Prickly pear (*Opuntia ficus-indica*):						
Young fronds	.070	.060	.010	.44	.37	.04
Old fronds	.062	.047	.015	.39	.29	.06
Kolu (*Acacia farnesiana*)	1.100	.976	.124	6.87	6.09	.58
Banana tops	.333	.287	.046	2.08	1.78	.21
Taro tops	.299	.246	.053	1.86	1.53	.25
Sweet-potato tops	.470	.352	.118	2.93	2.19	.38
Ti leaves (*Cordyline terminalis*)	.459	.404	.045	2.86	2.50	.21
ROOTS USED AS FORAGE.						
Cassava roots:						
Sample No. 1	.132	.059	.073	.82	.36	.34
Sample No. 2	.134	.100	.034	.83	.62	.16
CONCENTRATED FEEDS AND COMMERCIAL PRODUCTS.						
Brewers' grains	2.891	2.716	.075	18.06	16.97	.35
Molasscuit:						
Sample No. 2	.728	.350	.378	4.54	2.18	1.78
Sample No. 3 (sugar bran)	.364	.056	.308	2.27	.34	1.45
Algeroba or kiawe beans (*Prosopis juliflora*): Whole beans (beans and pods)—Sample No. 1	1.500	1.030	.470	9.37	6.43	2.21
Rice bran:						
Sample No. 1	1.140	.812	.328	7.12	5.07	1.54
Sample No. 2	1.820	1.680	.140	11.33	10.45	.66
Rice polish	1.980	1.620	.360	12.31	10.09	1.69
Cocoanut meal	3.360	3.020	.340	20.97	18.87	1.60

MINERAL CONSTITUENTS OF HAWAIIAN FEEDING STUFFS.[a]

In addition to the ordinary nutrients, animals require a certain amount of inorganic material, particularly lime and phosphoric acid. The requirements of a milch cow are stated to be approximately 0.09 pound phosphoric acid and 0.13 pound lime in addition to 0.24 pound potash per day.[b] It is usually taken for granted that these amounts will be supplied by any ordinary mixed ration and that animals will thus obtain all the ash constituents necessary.

Hals[c] estimates that a milch cow producing 11 quarts of milk per day will require at least 0.15 pound lime and 0.1 pound phosphoric acid, and states that as a general rule concentrated feeds are low in lime and high in phosphoric acid, while the opposite holds true with coarse fodders.

[a] For discussion of lime as an essential constituent of feeding stuffs, see Hawaii Sta. Press Bul. 15.

[b] H. P. Armsby, Manual of Cattle Feeding (1890), p. 434.

[c] Norsk Landmandsblad, 24 (1905), p. 567.

The analyses reported on preceding pages show that while Hawaiian feeding stuffs apparently contain normal amounts of other mineral constituents the lime content in many cases is low—so low, indeed, in some of the feeding stuffs that it would be impossible for an animal to eat enough green material to furnish even half of the required 0.13 pound. This is especially true with some of the samples of sorghum, Kafir corn, cane tops, and some of the meadow and pasture grasses. The following table, which summarizes some of the analytical data, will illustrate this point:

TABLE 10.—*Proportion of lime in some Hawaiian feeding stuffs.*

Kind of material.	Lime in feeding stuffs.	Amount of green feed required to furnish 0.13 lb. lime.	Kind of material.	Lime in feeding stuffs.	Amount of green feed required to furnish 0.13 lb. lime.
	Per cent.	*Pounds.*		*Per cent.*	*Pounds.*
Sorghum, sample No. 4	0.05	260	Cassava root, sample No. 1	0.07	185
Sugar-cane tops, sample No. 1	.01	1,300	Cassava root, sample No. 2	.04	325
Sugar-cane tops, sample No. 2	.04	325	Barnyard grass (*Panicum crus-galli*)	.02	650
Para grass, sample No. 1	.06	216	Hilo grass	.08	162
Para grass, sample No. 2	.08	162	Buffalo grass	.06	216
Para grass, sample No. 3	.09	144	Pilipiliuli	.02	650
Kafir corn, sample No. 1	.01	1,300	Kukaipua	.06	216
Kafir corn, sample No. 2	.04	325	Yard grass (*Eleusine indica*)	.04	325
Millet, sample No. 2	.04	325			

A number of samples of grasses, both wild and cultivated, were found to contain lime in excess of these figures. Thus, one sample of sorghum contained 0.15 per cent; two samples of guinea grass, 0.22 and 0.17 per cent, respectively; manienie or Bermuda grass, 0.14 per cent; *Paspalum dilatatum* (samples Nos. 1 and 2), 0.12 and 0.10 per cent, respectively; and pili grass, 0.26 per cent. While too few samples have been analyzed to warrant general statements as to average composition, the available data seem sufficient to warrant the conclusion that forage plants of the grass family grown in Hawaii are generally low in lime, while in some of them the proportion of this constituent is extremely small.

An ordinary ration is made up of concentrated feeds, as well as forage crops or other coarse fodders, and it might be assumed that these feeds would supply any deficiency of mineral matter as well as of protein. Too much reliance should not be placed on concentrated feeds, however, as available data show that some of those analyzed at the station were low in lime. Thus a sample of bran analyzed was found to contain only 0.07 per cent, while two samples of rice bran (Nos. 1 and 2) contained 0.15 and 0.08 per cent, respectively. Over 200 pounds of bran containing only 0.07 per cent lime would be required to supply the necessary 0.13 pound per day. The cocoanut meal analyzed contained only 0.08 per cent lime and the two samples of barley 0.05 and 0.10 per cent, respectively. It is easily seen from these figures that

such concentrates in the amounts ordinarily fed can not make good any deficiency of lime in a sorghum or grass ration. On the other hand, some of the leguminous forage crops analyzed were found to be decidedly higher in lime than grasses and so to be especially valuable as one of the constituents of a ration. Thus, two samples of alfalfa (Nos. 2 and 3) contained, respectively, 0.45 and 0.41 per cent lime, Spanish clover (*Desmodium uncinatum*) 0.19 per cent, and *Desmodium triflorum* 0.70 per cent. Two samples of ground algeroba beans (pods and seeds) contained, respectively, 0.28 and 0.34 per cent, and two samples of algeroba bean seeds 1 and 1.10 per cent, respectively. Many miscellaneous fodder materials furnishing higher percentages of lime may be mentioned, such as dried brewers' grains, with 0.25 per cent of this constituent; linseed meal, with 0.40 per cent; and molasscuit, with 0.86 and 1.07 per cent, respectively, in two of the samples analyzed.

This lack of lime in many of our grasses and forage plants may very possibly explain in large measure the failure to obtain the best results, a condition which sometimes follows the feeding of what was otherwise a properly balanced ration when judged by the chemical composition only.

The function of calcium in plant life is not very well understood. It is usually absent from young tissues and is found for the most part in the walls of adult cells, where it is present in organic combination. It may also be present as a by-product in the form of crystals of oxalate of lime deposited in the cells. The higher plants can not develop normally without lime, and for this reason it is regarded as being necessary for plant life.

As regards the function of lime in the animal, it forms an essential part in the bones, is present to a greater or less extent in the ash constituents of the organs and tissues, and is abundant in milk. More than 2 per cent of the live weight of a full grown, well-fed steer is lime. Cows' milk contains more lime than does limewater, the amount present being generally in excess of 0.15 per cent, while limewater saturated at 80° F. contains about 0.09 per cent. Lime constitutes about 20 per cent of the ash of milk, and generally more than 1.5 per cent of the total solids.

A lack of lime in food will result in improper bone development in the growing animal. This impaired development of the bony skeleton will, of course, react on the general growth of the animal, and the purpose for which the animal is fed, whether it be the production of beef, or milk, or of work, will not be attained. In extreme cases a diseased condition of the body may result.

Lime enters the animal body both in food and drink. All flowering plants contain some lime, as do almost if not all natural waters. Surface waters, however, in Hawaii, except in coral formations, contain

but small amounts of lime or other mineral ingredients. Whether lime in the form of purely mineral salts, such as carbonate or sulphate present in water, is as good a source of lime for the animal as the organic combination present in plants is not definitely known.

In fodder plants and other feeding stuffs the variation in lime content is quite wide, as noted above. There are three factors influencing this variation which should be considered in this connection:

(1) Different species of plants growing under the same conditions have the power of taking up from the soil and incorporating in the plant tissues different amounts of inorganic substances. As an example of this, sorghum and alfalfa growing side by side were found on analysis to contain mineral constituents as follows: Sorghum—potash, 0.41 per cent; lime, 0.05 per cent, and phosphoric acid, 0.15 per cent; alfalfa—potash, 0.84 per cent; lime, 0.45 per cent, and phosphoric acid, 0.30 per cent.

(2) Plants of the same species grown upon different soils may contain different amounts of ash ingredients. If an ash ingredient is present in the soil in a soluble form in large excess over the needs of the plant the plant tissues will contain an excess of this ingredient. A marked example of this was noted in comparing sisal fiber from Sisal Plantation with a similar specimen from the experiment station. The total ash in each was approximately the same. In the case of the fiber from Sisal Plantation, where the soil is disintegrated coral, 40 per cent of the ash was lime, while in that from the experiment station, where the soil contains less than 1 per cent lime, the amount in the sisal ash was but 7 per cent.

(3) Different parts of the same plant contain different amounts of ash ingredients. In other words, the mineral matter taken from the soil becomes localized in the plant. Seeds are rich in phosphorus, leaves and straw in potash, and old mature cells richer in lime than growing parts.

It may be said in general that a deficiency of lime in fodder may be met by growing a larger proportion of leguminous crops for green fodder; by feeding such concentrates as algeroba beans and waste molasses or products made from it; by supplying limewater or natural water containing more lime, and by the application of lime, or fertilizers containing lime, to soils used for growing forage crops of the grass family. Possibly leached-wood ashes sprinkled over the fodder might also prove useful, as has been suggested by some writers.

For range cattle the introduction of legumes on the ranges, or such grasses as may be found to take more lime from the soil, are the most obvious remedies.

Hals[a] suggests that a deficiency in lime may be remedied by adding suitable mineral matter to the ration, precipitated dibasic calcium

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[a] Loc. cit.

phosphate being considered superior for the purpose to bone meal, bone ash, or similar very indigestible materials.

Cases are on record in Hawaii where cattle have become diseased from the lack of lime in grass fodder. When such conditions, indicated by emaciation, soft bones, etc., arise a veterinarian should be consulted.

CONCLUSION.

While the analyses reported in this bulletin are not considered sufficiently numerous to warrant any extended comparison of Hawaiian feeding stuffs with one another or with those of other regions, or to justify elaborate discussion of the best ways of utilizing the various feeding stuffs in Hawaiian practice, they do show that the Hawaiian feeder has at his command a quite large and varied assortment of feeding stuffs, many of which are of high nutritive value, and it is believed that the information given in the bulletin will aid the feeder in selecting from the feeding stuffs available those which will give him the cheapest and most efficient rations for his stock.

A fact of special significance brought out by the bulletin is that Hawaiian feeding stuffs, especially those of the grass family, are as a rule deficient in lime and that in order to get the best results in bone development, health, etc., of animals, these feeding stuffs should probably be supplemented by others richer in lime, such as leguminous plants, algeroba beans, sugarhouse (molasses) wastes, or by the use of more lime either in the drinking water, mixed with the feeds used, or applied to the soils growing the forage crops.

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